Course Introduction

CHEM 361A: Introduction to Physical Chemistry

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Lecture 1

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Learning Objective: Review key concepts in chemistry, physics and mathematics which will be employed throughout the course.

References:

- Atkins and de Paula Topic 1A

Course Themes and Goals

The course is broken down into three major sections

1. Thermodynamics - Foundational Concepts
2. Equilibrium - The Steady State
3. Kinetics - How Fast the Steady State is Achieved

Note that the order is the opposite as in General Chemistry. In this course we will start with the foundational concepts and build the applications from them.

I have three major goals

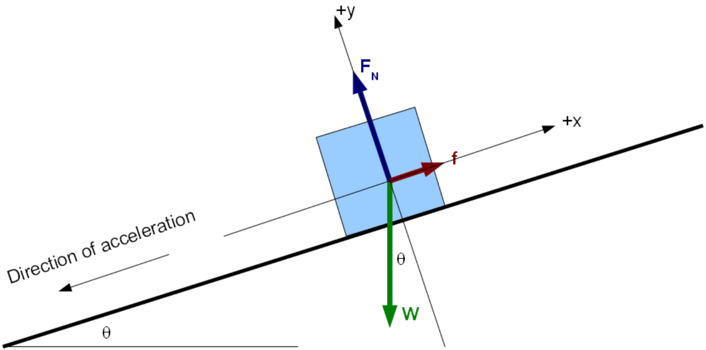
1. Illustrate the connections between math and science
2. Demonstrate when theories are valid and when they fail
3. Push you to think of physical systems in the context of the foundational concepts and their applications

Teaching Philosophy

1. Flipped classroom and active learning
2. In evaluations demonstrate your knowledge
3. During the semester, you are allowed to have a bad day
4. If you think there is a problem with how I evaluated you, ask
5. All grades are posted to TITANium. What is posted there will be your final grade
6. This is not a calculus course, but you are expected to be able to use it
7. Questions regarding course content will most likely be answered on the course discussion board

Force

$$\text{Force} = \text{mass} \times \text{acceleration} \qquad \sum F = ma$$



Work

Work is done when an object is moved a distance against an opposing force:

$$\text{Work} = \text{force} \times \text{distance}$$

The units for work are N·m or J

Suppose you wanted to lift a 1kg box 1m. How much work was done?
Hint: $\vec{a}_g = 9.81 \text{ m/s}^2$

Energy

Energy is the capacity to do work. It is measured in Joules (J).

Kinetic Energy

Energy of a body due to its motion

$$E_k = \frac{1}{2}mv^2$$

Potential Energy

Energy of a body due to its position and the force acting on it. For example:

- When the force is gravity then

$$E_p = mgh$$

The total energy is:

$$E = E_k + E_p$$

Pressure

Pressure is a measure of a force exerted over a defined area.

$$p = \frac{F}{A}$$

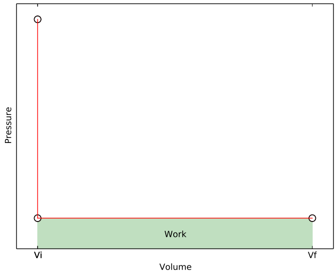
Pressure units and conversion factors

pascal, Pa	$1 \text{ Pa} = 1 \text{ N m}^{-2}$
bar	$1 \text{ bar} = 10^5 \text{ Pa}$
atmosphere, atm	$1 \text{ atm} = 101.325 \text{ kPa}$
	$1 \text{ atm} = 1.01325 \text{ bar}$
torr, Torr	$760 \text{ Torr} = 1 \text{ atm}$
	$1 \text{ Torr} = 133.32 \text{ Pa}$

Conceptual Problem

When on thin ice, what is the best way to avoid falling in?

Pressure $\times$ ΔVolume $=$ Work

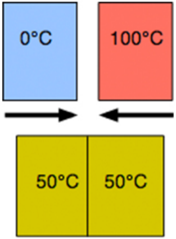


We will soon use the fact that Pressure $\times$ ΔVolume determines the transfer of energy (work) of an expansion or compression. This relationship is seen by:

$$
\begin{aligned}
p\Delta V &= \frac{N}{m^2} \cdot m^3 \\
&= N \cdot m \\
&= J
\end{aligned}
$$

Heat and Temperature

- **Heat** is a transfer of energy as a result of the chaotic motion of particles
- The **temperature** of an object determines the flow of heat when in contact with another object.



Conversion between Celsius and Kelvin

$$T/K = \theta/^{\circ}C + 273.15$$

Practice: Express normal body temperature (37°C), in Kelvin.

Measures of Concentration

Two measures of concentration will appear regularly in this course:

1. Molar Concentration [Y] (mol/dm^3 or mol/L): Amount of Y (mol) per volume of *solution* (L or dm^3)

$$[Y] = \frac{n_Y}{V}$$

2. Molality b_Y (mol/kg): Amount of Y (mol) per mass of *solvent*

$$b_Y = \frac{n_Y}{m_{solvent}}$$

Mole Fraction

1. Mole Fraction x_Y (dimensionless): Fraction of Y (mol) in the n molecules of the mixture (mol)

$$x_Y = \frac{n_Y}{n}$$

What is the mole fraction of glucose molecules, $C_6H_{12}O_6$ in 0.140 mol/kg $C_6H_{12}O_6(aq)$?

Hint: Molar Mass $H_2O = 18.02$ g/mol, molar mass of $C_6H_{12}O_6 = 180.16$ g/mol

Molar Volume

The molar volume of any substance, is the volume it occupies per mole of molecules:

$$V_m = \frac{V}{n}$$

Gas	V_m (L mol^{-1})
Ammonia	24.8
Argon	24.4
Carbon Dioxide	24.6
Nitrogen	24.8
Oxygen	24.8
Hydrogen	24.8

The Molar Volume of gases at standard ambient temperature and pressure (SATP: 298.15 K and 1 bar)

Summary

I have three major goals

1. Illustrate the connections between math and science
2. Demonstrate when theories are valid and when they fail
3. Push you to think of physical systems in the context of the foundational concepts and their applications

- We will build upon core physical concepts such as Work, Pressure, Heat and Temperature to define chemical systems.
- Read the Syllabus for more details on the course
- Review the calculus concepts presented in the Khan Academy videos